INDOOR AIR QUALITY ASSESSMENT

Green Meadow Elementary School
Great Road
Maynard, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
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Background/Introduction

At the request of a parent, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) was asked to provide assistance and consultation regarding indoor air quality issues and health concerns at the Green Meadow Elementary School in Maynard, Massachusetts.

On March 12, 2002, Cory Holmes, Environmental Analyst of the BEHA Emergency Response/Indoor Air Quality (ER/IAQ) Program, conducted an indoor air quality assessment. Gerald Collins of the Maynard Health Department accompanied Mr. Holmes during the assessment. The building was previously evaluated by Elise Comproni of BEHA in 1990 and a report was issued indicating problems that were identified at that time (MDPH, 1990). The report recommended increasing both supply and exhaust ventilation and that solar heat load be appropriately controlled to improve comfort. As a result of the MDPH report a ventilation engineering firm was hired by the Maynard School Department to inspect the ventilation equipment, univent controls and dampers as well as all exhaust vents to ensure proper function (DiNisco Kretsch, 1990).

The school is a single-story brick building built in 1956. An addition was constructed in 1974 followed by a more recent addition in 1988. The school consists of general classrooms, an art room, a music room, offices, gymnasium, library and cafeteria.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551. Moisture content of building materials was measured with a Delmhorst, BD-2000 Model, Moisture Detector with a Delmhorst Standard Probe.

Results

This elementary school houses pre-kindergarten through grade 3, with a student population of approximately 600 and a staff of approximately 55. Tests were taken under normal operating conditions and results appear in Tables 1-5.

Discussion

Ventilation

It can be seen from the tables that the carbon dioxide levels were elevated above 800 ppm (parts per million) in thirteen of thirty-eight areas surveyed, indicating ventilation problems in these areas of the school.

Fresh air in classrooms is supplied by wall-mounted unit ventilators (univents) (see Figure 1). Univents draw air from outdoors through a fresh air intake located on the exterior walls of the building and return air through an air intake located at the base of each unit. The mixture of fresh and return air is drawn through a filter and a heating coil, and is then expelled from the univent by motorized fans through fresh air diffusers. Univents were not operating in a few of the areas surveyed (see Tables). Obstructions to airflow, such as books, papers and posters on top of univents, as well as desks and carts in front of univent return vents, were seen in a number of classrooms (see Picture 1). To function as designed, univent fresh air diffusers and return vents must remain free of obstructions. It is important that these units be activated and allowed to operate during school hours.

Ventilation in the gymnasium, cafeteria, interior rooms and offices is provided by air handling units either located in mechanical rooms or on the roof. These units were operating during the assessment.

The mechanical exhaust ventilation system in the new addition consists of wall-mounted vents. The location of some exhaust vents can limit exhaust efficiency when the classroom hallway doors are open (see Picture 2). When a classroom door is open, exhaust vents will tend to draw air from both the hallway and the classroom. The open hallway door reduces the effectiveness of the exhaust vent to remove common environmental pollutants from classrooms.

Exhaust vents in the original building are located in the ceilings of coat closets and are activated by wall switches (see Picture 3). A number of these vents were deactivated during the assessment. Without the exhaust system operating as designed, normally occurring pollutants cannot be removed allowing them to build up and lead to indoor air quality/comfort complaints. Classroom air is drawn into the coat closet via an undercut below the closet door. This design allows for the vents to be easily blocked by stored materials. In a number of classrooms, these vents were blocked with books, book bags, boxes and other obstructions (see Picture 4). In order to function properly, these vents must remain free of obstructions.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a univent and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last balancing of these systems was not available at the time of the assessment. It is recommended that HVAC systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (BOCA, 1993; SBBRS, 1997). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches (see Appendix I).

Temperature readings were within a range of 70^{o} F to 74^{o} F, which were within the BEHA recommended range. The BEHA recommends that indoor air temperatures be maintained in a range of 70^{o} F to 78^{o} F in order to provide for the comfort of building occupants. A number of temperature control complaints were expressed to BEHA staff

during the assessment, which may indicate that thermostats are malfunctioning and may need repair/replacement. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity in this building was below the BEHA recommended comfort range in all areas sampled. Relative humidity measurements ranged from 21 to 29 percent. The BEHA recommends that indoor air relative humidity is comfortable in a range of 40 to 60 percent. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

A perimeter inspection of the building was conducted in which BEHA staff noted a moisture penetration problem due to the lack of a complete roof drainage system. Picture 5 depicts a green organic material (possibly moss or algae) growing on exterior brickwork on the rear of the building. The pattern and location of growth is consistent in areas that are not equipped with gutters or downspouts. The lack of proper drainage allows back-splashing rainwater to impact on the ground below and chronically wet the exterior walls. Gutters and downspouts are designed to collect and direct rainwater away from the base of the building to prevent the chronic wetting of exterior walls which can result in damaged brickwork and/or mold growth. Over time rainwater can work its way into mortar and brickwork causing cracks and fissures, which can lead to water penetration as well as the increased degradation of the structural integrity of the building.

Several classrooms had a number of plants. Moistened plant soil and drip pans can be a source of mold growth. The lack of drip pans can lead to water pooling and mold growth on windowsills. Plants are also a source of pollen. Plants should be located away from the air stream of ventilation sources to prevent the aerosolization of mold, pollen or particulate matter throughout the classroom.

Some water-damaged ceiling tiles were noted resulting from historic roof leaks (see Picture 6). If wetted repeatedly, porous materials can grow mold and be a source of unpleasant odors. Water-damaged building materials should be replaced after a water leak is discovered. Water damaged ceiling tiles in the level three hallway and the carpeting directly below it, were tested for moisture content. No elevated levels of moisture were detected. The American Conference of Governmental Industrial Hygienists (ACGIH) recommends that carpeting be dried with fans and heating within 24 hours of becoming wet (ACGIH, 1989). If carpets are not dried within this time frame, mold growth may occur. Water-damaged carpeting cannot be adequately cleaned to remove mold growth.

In a number of classrooms, paper products, board games and other porous items were found stored underneath sinks. If these items become wet repeatedly they can provide a medium for mold growth. These items should be relocated to a warm, dry environment.

Other Concerns

Several other conditions were noted during the assessment, which can affect indoor air quality. Cleaning products and other materials were found on counter-tops and beneath sinks in a number of classrooms (see Picture 7). Several classrooms also contained unlabeled spray bottles. Products should be kept in their original containers or

clearly labeled as to their contents for identification purposes in the event of an emergency. Cleaning products contain chemicals that can be irritating to the eyes, nose and throat of sensitive individuals.

Also of note was the amount of materials stored inside classrooms. In classrooms throughout the school, items were observed to be piled on windowsills, tabletops, counters, bookcases and desks. The large number of items stored in classrooms provide a source for dusts to accumulate (see Picture 8). These items, (e.g., papers, folders, boxes, etc.) make it difficult for custodial staff to clean. Dust can be irritating to the eyes, nose and respiratory tract. These items should be relocated and/or cleaned periodically to avoid excessive dust build up. A number of exhaust vents in classrooms, restrooms and in common areas had accumulated dust on their grills. If exhaust vents are not functioning, backdrafting can occur, which can re-aerosolize dust particles. In addition, these materials can accumulate on flat surfaces (e.g., desktops, shelving, and carpets) in occupied areas and subsequently be re-aerosolized, causing further irritation.

Several classrooms contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may contain volatile organic compounds (VOCs), (e.g. methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve) (Sanford, 1999), which can be irritating to the eyes, nose and throat.

Several areas contained lamination machines and/or photocopiers. Lamination machines give off odors. Volatile organic compounds (VOCs) and ozone can be produced by photocopiers, particularly if the equipment is older and in frequent use. Ozone is a respiratory irritant (Schmidt Etkin, D., 1992). Exhaust ventilation was not activated during the assessment. Local exhaust ventilation should be operating while equipment is in use to help reduce excess heat and odors in these areas.

A number of display hornet/wasp's nests were noted in classrooms (see Picture

9). Several rooms contained animals such as lizards and hamsters. Animal dander and insect parts can become dried out, aerosolized and may serve as sources of allergenic material for sensitive individuals.

Several areas contained window-mounted air conditioners. This equipment is normally equipped with filters, which should be cleaned or changed as per the manufacturer's instructions to avoid the build up and re-aerosolization of dirt, dust and particulate matter.

The art room contained a kiln that was equipped with local exhaust ventilation. However the flexible ductwork was not connected to the vent (see Picture 10). Pottery kilns can produce carbon monoxide and sulfur dioxide, which can cause respiratory symptoms in exposed individuals (McCann, M., 1985). The current condition of the kiln exhaust presents the opportunity for kiln emissions to enter occupied areas if the kiln is activated.

Conclusions/Recommendations

In view of the findings at the time of our inspection, the following recommendations are made:

1. Examine each univent for function. Survey classrooms for univent function to ascertain if an adequate air supply exists for each room. Consider consulting a heating, ventilation and air conditioning (HVAC) engineer concerning the calibration of univent fresh air control dampers school-wide.
2. Activate exhaust ventilation in occupied areas. Repair and/or replace exhaust ventilation motors where necessary. Consider replacing wall switches controlling exhausts with key switches (see Picture 11 for an example).

3. Remove all blockages from univents and exhaust vents to facilitate airflow. Consider removing coat closet doors to prevent blockage or re-locating passive door vents to the top of coat closet doors to improve exhaust ventilation.

4. Consider having the systems re-balanced every five years by an HVAC engineering firm.

5. Calibrate, repair and/or replace thermostats as necessary to maintain control of comfort.

6. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a HEPA filter equipped vacuum cleaner in conjunction with wet wiping of all non-porous surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

7. Keep plants away from univents in classrooms. Ensure plants have drip pans and examine drip pans for mold growth. Disinfect areas with an appropriate antimicrobial where necessary.

8. Repair any water leaks and replace any remaining water-stained or missing ceiling tiles. Examine the areas above and behind these tiles for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial.

9. Clean and maintain aquariums and animal cages to prevent bacterial/mold growth and/or odors.

10. Inspect/install drainage to prevent the impact of back-splashing rainwater on exterior brickwork. Remove growth and disinfect areas on exterior brickwork with an appropriate antimicrobial as needed.

11. Do not store paper products or other cellulose-containing materials beneath sinks.

12. Store cleaning products and chemicals properly and keep out of reach of students.

13. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.

14. Ensure exhaust ventilation is functioning in areas that contain lamination machines and photocopiers.

15. Periodically clean exhaust vents of accumulated dust and debris.

16. Keep hornet/wasp's nest away from univents to prevent the aerosolization of potentially allergenic materials. Consider bringing in items on an "as needed" basis.

17. Do not activate kiln until local exhaust ventilation ductwork is properly installed.

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Picture 1

Materials Obstructing Airflow of Classroom Univent

Picture 2

Location of Classroom Wall Mounted-Exhaust Vent in Relation to Hallway Door

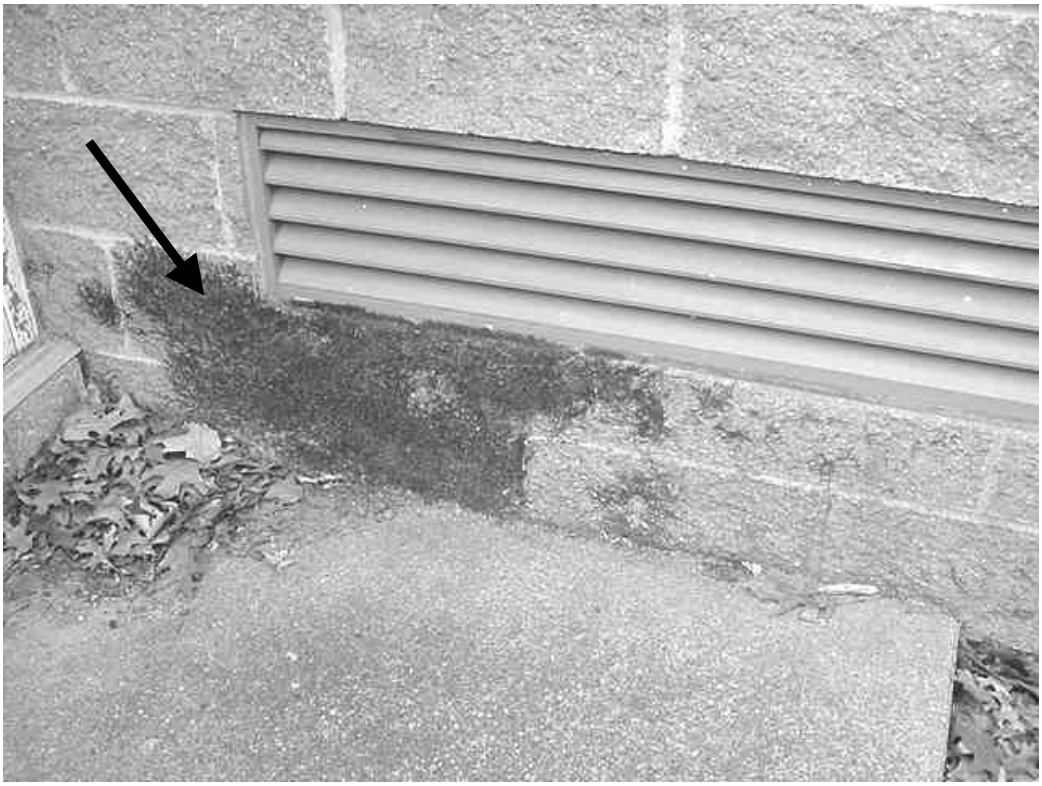
Picture 3

Classroom Wall Switch Controlling Exhaust Vent in Coat Closet

Picture 4

Coat Closet Exhaust Vent Blocked by Stored Items

Picture 5



Moss Growth due to Splashback near Univent Air Intake on Rear of Building

Picture 6

Water Damaged Ceiling Tiles

Picture 7

Cleaning Products Stored beneath Unlocked Classroom Sink

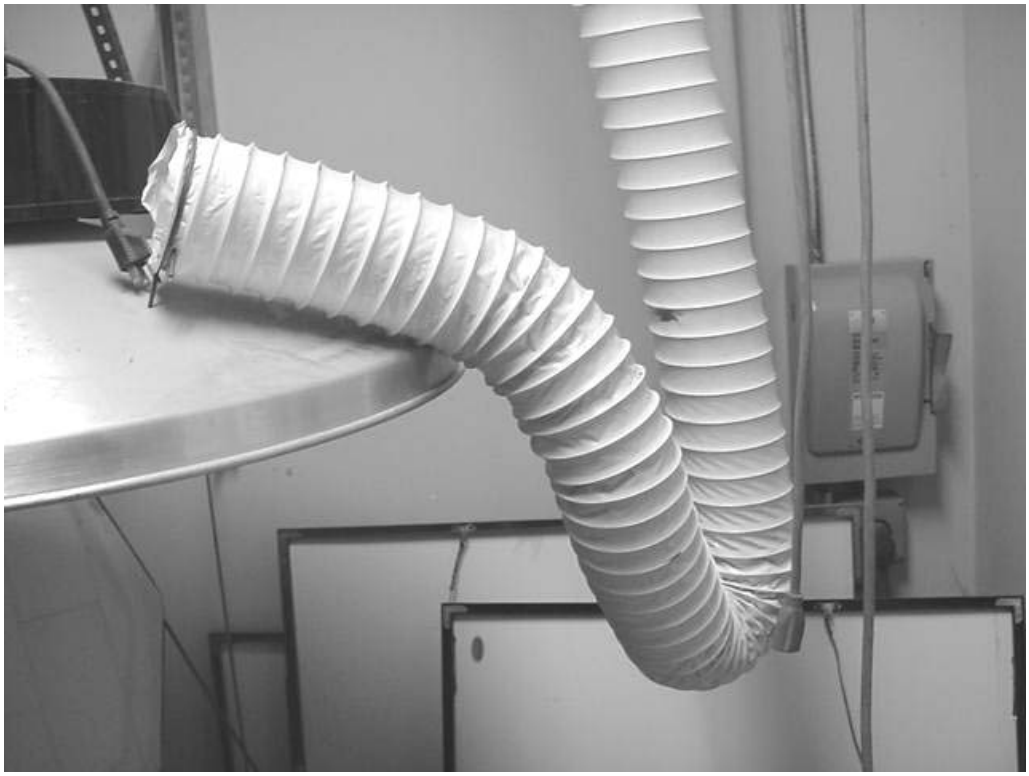
Picture 8

Accumulated Items in Classroom

Picture 9

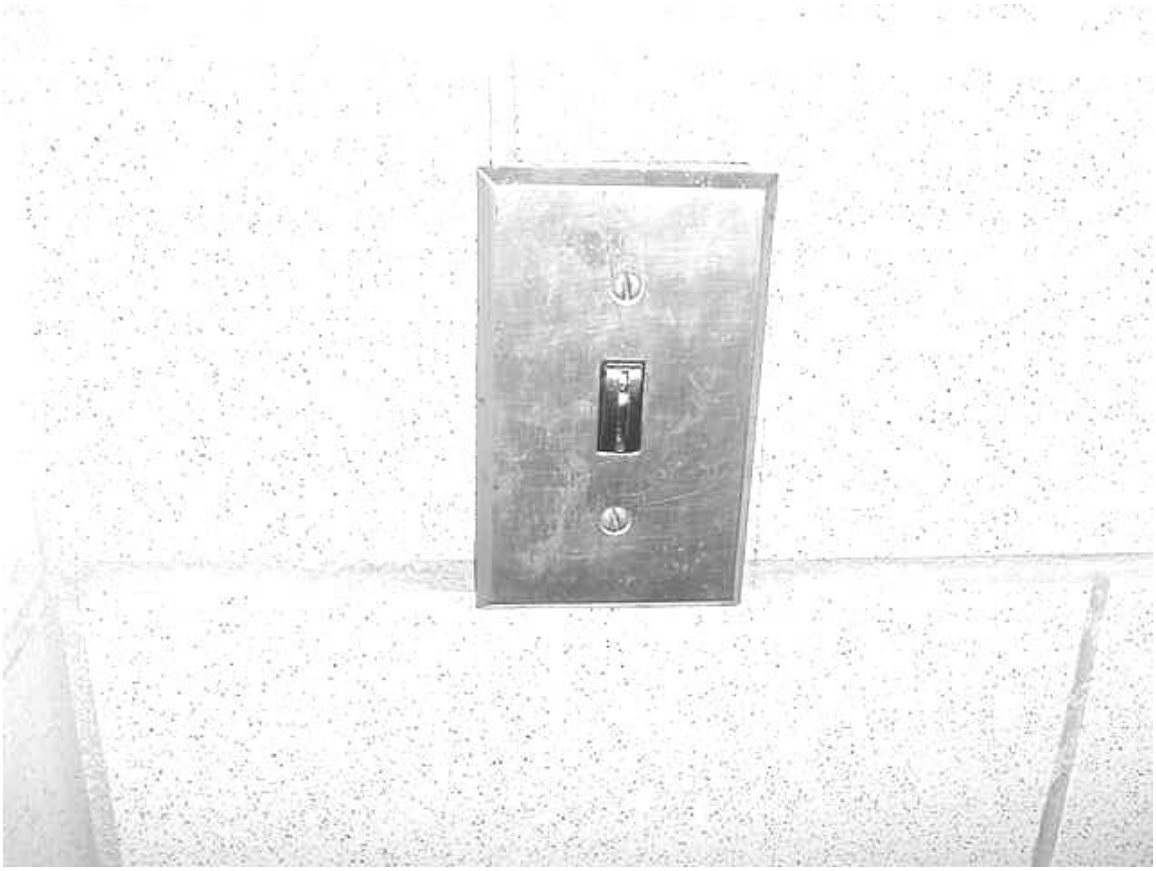
Hornet/Wasp's Nests in Classroom

Picture 10



Flexible Kiln Duct Detached from Local Exhaust Vent

Picture 11



Example of Key Switch

TABLE 1

Indoor Air Test Results – Green Meadow Elementary School, Maynard, MA – March 12, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	360	40	39					Cold, overcast, wind 10-15 mph
Art Room	661	70	22	16	Yes	Yes	Yes	8+ plants, plant over univent, door open, accumulated items, exhaust vent near hall door, kiln not connected to flex-duct, cleaning products under sink, hornet/wasp nest
Weksner	790	73	24	22	Yes	Yes	Yes	Univent return obstructed by cart, window mounted air conditioner, spray cleaner/bleach under sink, 2 large hanging wasp nests
1A	788	73	22	20	Yes	Yes	Yes	
1B	673	73	21	2	Yes	Yes	Yes	22 occupants gone ~15 mins., door open, cleaning product under sink
2D	992	71	23	22	Yes	Yes	Yes	Wasp nest, thermostat set at 75º F
Star Program	615	72	21	9	Yes	Yes	Yes	Door open
2C	881	73	23	19	Yes	Yes	Yes	Cleaning product on counter, door open

*** ppm = parts per million parts of air**
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 2

Indoor Air Test Results – Green Meadow Elementary School, Maynard, MA – March 12, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
2E	590	73	21	0	Yes	Yes	Yes	
2B	640	73	22	0	Yes	Yes	Yes	Obstructions around univent
3A	782	73	23	20	Yes	Yes	Yes	Door open, iguana, hamster, incubator/eggs, accumulated items, cleaning products on/under sink, staffed animals
3B	909	72	24	19	Yes	Yes	Yes	Unlabeled cleaning product on sink, incubator/eggs, univent obstructed by items
Hallway – level 3								6 water-damaged CT – historic leak, *moisture reading of carpet = 0.00
Boy's Restroom						Yes	Yes	
3D	641	73	22	2	Yes	Yes	Yes	
4D	909	74	22	22	Yes	Yes	Yes	Door open, 2 plants, blockage around univent, spray cleaner on counter

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TABLE 3

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Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
4A	899	74	23	25	Yes	Yes	Yes	Accumulated items
4B	536	73	21	0	Yes	Yes	Yes	Cleaning product on sink-paper/cardboard under sink, univent blocked by items
5C	944	74	24	27	Yes	Yes	Yes	
Meade	915	72	23	17	Yes	Yes	Yes	
5A	990	72	24	22	Yes	Yes	Yes	Wasp nest, door open, cleaning product on desk
Former Conference Room	1000	72	25	0	Yes	Yes	Yes	Univent not operational – changed fuse
6C	670	73	24	3	Yes	Yes	Yes	Plant on paper towel
Smart	684	73	24	15	Yes	Yes	Yes	Exhaust turned off-wall switch (activated), cleaning product on desk/sink counter, large wasp nest, items obstructing univent diffuser
7	757	73	23	16	Yes	Yes	Yes	

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TABLE 4

Indoor Air Test Results – Green Meadow Elementary School, Maynard, MA – March 12, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
McCarthy	714	74	23	17	Yes	Yes	Yes	Door open
4	778	73	23	16	Yes	Yes	Yes	Door open, window mounted air conditioner-dirty filter, 2 water damaged CT, 2 rooms connected
9	729	72	23	17	Yes	Yes	Yes	Obstructions to univent
Caresti	901	72	23	0	Yes	Yes	Yes	Obstructions to univent, univent off-heat issues (HVAC contractor contacted-air leak), exhaust vent obstructed by stored items
Avery	640	71	22	14	Yes	Yes	Yes	Exhaust off, window and door open
K2	810	72	24	31	Yes	Yes	Yes	Door open, air conditioner, double room, exhaust fan not functioning
Cafeteria	858	74	29	200+	Yes	Yes	Yes	Exhaust off
Cohen	796	74	26	3	No	Yes	Yes	4 water damaged CT, window mounted air conditioner
Music Room	949	74	24	24	Yes	Yes	Yes	Chorus activity

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TABLE 5

Indoor Air Test Results – Green Meadow Elementary School, Maynard, MA – March 12, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Teacher's Workroom	682	74	24	1	No	Yes	Yes	2 rizographs, 1 photocopier, exhaust fan non-operational, ozone/photocopier odors
Teacher's Lounge	549	71	22	0	Yes	Yes	No	Area subdivided
Smith	518	70	22	3	Yes	Yes	No	Area subdivided
Smith – back room	572	72	23	0	No	No	Yes	Area subdivided
Gym	402	70	22	21	No	Yes	Yes	
Main Office	715	74	26	6	Yes	No	No	Openable windows in adjacent offices, wall mounted air conditioner
Hallway – exhaust vent	600	73	22	3	Yes	No	Yes	Exhaust deactivated
Perimeter Notes								Missing some gutters, missing downspout, moss growth on building

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